Farming of the anadromous shad, *Tenualosa ilisha*: Signs of taking off in India

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Clupeids are important food fishes in high demand and hence are heavily exploited across the World. Most tropical clupeids are un-domesticated and caught from the wild. The species, *Tenualosa ilisha*, belonging to the family Clupeidae, is an economically important food fish in India, Bangladesh, Myanmar, Arabian countries, Pakistan, Malaysia, Thailand, Viet Nam, and Sri Lanka. Locally called hilsa, the species forms a rich fishery worth over US$ 2.0 billion in the northern Bay of Bengal and associated rivers in India, Bangladesh, and Myanmar[1]. By nature, the species is anadromous; spawns in freshwater stretches of rivers and the juveniles migrate to saline offshore waters for growth and maturation and again migrate back to freshwater stretches of rivers for spawning. The populations of the species are declining globally[2], largely due to overexploitation and habitat modifications. Its fishery has drastically declined in the Bay of Bengal bordering India[3]. Considering the excessive demand and very high market price of the fish and to ease fishing pressure on its wild stocks, there have been efforts for domestication and farming of the species in India, besides legislated natural stock management efforts. The early efforts on breeding, larval rearing and grow out in captivity of the species were not measurably successful[4]. However, the momentum on developing captive breeding and farming technologies for the species have been re-invigorated with research funding from the Indian Council of Agricultural Research (ICAR), New Delhi, through a multi-disciplinary and multi-institutional project, 'Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)' since 2012.

Pond rearing

Under the above project, captive rearing trials were started in freshwater ponds, of which, this study involved a freshwater pond of 0.5 ha area having 1.5 m water depth, situated along the bank of the Bhagirathi-Hooghly river at Godakhali, South 24 Parganas District, West Bengal.

The trial was conducted to generate the much needed biological, nutritional, physiological and environmental data on pond culture for standardisation. The pond was cleared of all macrophytes and predatory fishes by repeated netting and complete drying of the pond until the bottom soil cracked. After ploughing and shaping, water from the river was let into a settling pond to remove excess sediments and undesired flotsam. Water was then let into the culture pond and the excess water was let out through the outlet. Sluices fitted with steel wire meshes (0.5 to 2 cm mesh) were installed at the water entry and exit points for prevention of entry of unwanted fishes into the pond and escape of the stocked hilsa. The water quality was monitored regularly. The pond received tidal water influx during high tides through the sluice gate. Among

A day's catch of hilsa from Tipi wetland.

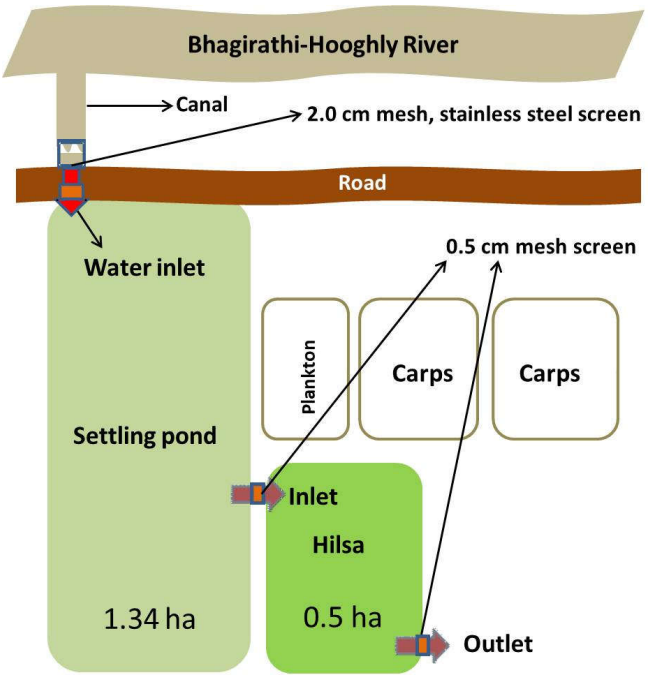
the 26 water quality parameters monitored simultaneously in the river stretch and the pond water, the water current, depth, and turbidity were significantly lower in the pond, while calcium and total hardness were marginally higher, rendering the pond water quality largely suitable for the species.

When the pond rearing trials began, the artificial breeding and seed production experiments were in the initial stages and started in parallel, and thus hatchery produced seeds for stocking and grow out rearing were not ready. Hence, for stocking in the experimental grow out pond,

Netting for sample collection.

the seed materials were collected from natural sources during July-September. Juveniles were collected from the Bhagirathi-Hooghly River flowing nearby, using drag nets and lift nets of small meshes involving regular hilsa fishers and transported to the pond in well aerated circular containers of 500 l capacity. All possible care was taken to reduce stress to the fish during capture and transportation. The stocking size was 7.12±1.25 cm total length (TL) and 5.85±1.5 g in weight. The stocking density was 1,000/ha, considering the fast moving, plankton feeding nature of the fish and paucity of prior knowledge on appropriate stocking density. The river water brought natural food items of the species such as plankton into the pond, and plankton was also supplemented by collecting it from adjacent ponds fertilised in line with the culture of Indian major carps. The rearing trial was conducted for 22 months with a daily supply of plankton dominated by diatoms, copepods and cladocerans, which are among the major food items of the species. The length and weight increments were monitored monthly by sample netting.

From the initial size of stocking, the fishes grew to 31.2±2.6 cm TL and 301.0±15 g weight at the end of the trial. Being a clupeid, highly sensitive and having un-domesticated instincts, there were mortalities while netting and also due to other unknown causes. The dead specimens were usually found afloat after extensive decomposition, which constrained identification of the causes of mortality. The survival at the end of the trial was 23%. Due to the fast moving nature of the species, maintaining them in small land-based holding systems has been challenging. The low survival might have been due to some inadequacy in water quality, food availability or confinement of the pond. Extensive pond rearing trials are underway to standardise pond-based farming of the species.



Schematic layout of the ponds used for rearing hilsa.

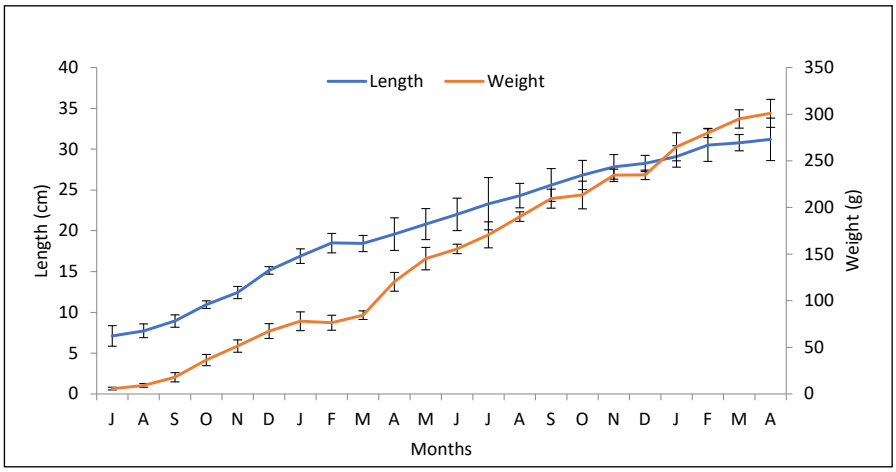
Sample collection for growth monitoring.

Potential for stocking in wetlands

Though the species needs two different environments (saline and freshwater) during different stages of its life cycle, it has the potential to adapt to completely freshwater or low saline environments as evident from it being reported from wetlands[5,6]. This was also supported by an incidental harvest of the species during the study period, in large numbers in commercial sizes from a floodplain wetland, locally called Tipi wetland, connected to the eastern bank of the river Ichamati in West Bengal. The wetland is about 120 km away from the sea face and within the tidal range from the Bay of Bengal. Having an area of 37.50 ha, the wetland receives water from river Ichamati and gets naturally stocked with freshwater and brackish water finfishes and shellfishes.

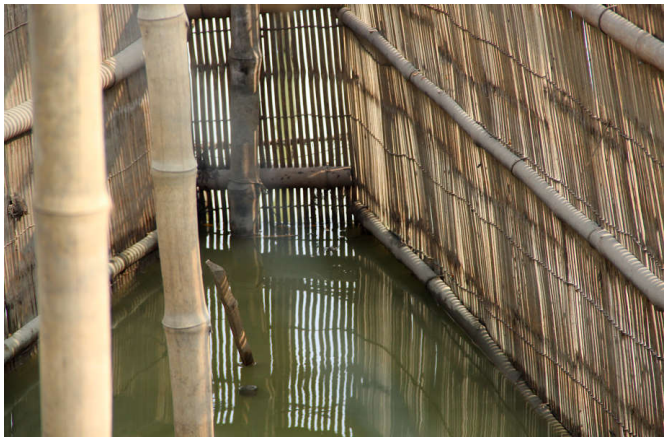
Water quality monitoring in the pond.

Growth progression of hilsa reared in freshwater grow-out pond.



Size at harvest of hilsa from Tipi wetland.

Pond reared hilsa at marketable size.


Split bamboo screen sluice installed at water inlet.

Organised stocking of Indian major carps (*Gibilion catla*, *Cirrhinus mrigala* and *Labeo rohita*) along with exotic fish species (*Cyprinus carpio*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Oreochromis niloticus*) was also being practised by the wetland managers under a culture-based fisheries management mode, involving stocking and recapture of the stocked fish. The wetland maintained a depth of 1 to 1.5 m at minimum water level, which went up to 2.5 m during tidal feeding at high tides. The wetland has a majority sandy clay bottom and is devoid of dense macrophytes (as maintained by the wetland managers). The water quality was similar to fluvial ecosystems. The salinity, however, goes up to 9.0 ppt during April-May. The primary productivity estimated was 6.0 gC/m^3/day, which indicated a moderate to highly productive nature. The wetland supported rich plankton resources with an abundance of diatoms, copepods and cladocerans. Water inlet and outlet to the wetland were managed through a connecting channel, regulated by a sluice gate fitted with bamboo mesh screens lined with HDPE net material.

Fishing in the wetland is seasonal from November to February, allowing the stocked fish seeds to grow to commercial sizes over a year. The total annual fish catch from the wetland was 45,000 to 60,000 kg, forming a yield of 1,216 to 1,621 kg/ha/year. Though hilsa has not previously been recorded from the wetland, a large quantity of it appeared in catches from the wetland during December 2015. The leaseholder of the wetland, Mr. Sanjoy Biswas, explained that when intensive fishing began in December, along with other stocked fish species, *T. ilisha* of marketable sizes appeared in 10 to 25 specimens each in daily catches, consecutively for a week. The total harvest of hilsa was 110 kg and was sold off at INR 400/kg, which was higher than the expected price of the stocked carps harvested. We recorded 22 specimens of at the size range 28.5 to 33.4 cm TL and 225.5 to 378.8 g in weight in a day's catch from the wetland. It appeared that the larval stages of hilsa have entered the wetland through the screens of the sluice gate during the breeding season (September-October) and grew in the wetland until the harvest in December next year. This showed that the rate of growth was faster in the wetland compared to the trial conducted in pond rearing. The ecological conditions of the wetland being fresh to mildly brackish and the availability of abundant food organisms, as well as the vast area for movement, must have supported the fast growth of the species in the wetland. This incident suggested the possibility of stocking the species in wetlands of similar nature to successfully grow up to marketable sizes.

Prospects

The encouraging rate of growth of the species in pond rearing trial and the harvest of auto stocked hilsa from the wetland demonstrated the potential of the species to grow in landlocked fresh to slightly saline water bodies to attain marketable sizes in one to one and half year. The possibility of utilising large wetland ecosystems for farming of the species, along with major carps would revolutionise hilsa production, once an adequate quantity of seed is available for stocking. Demonstrable captive breeding and seed production achievements having been made through stripping natural brooders[7,8,9] and the remarkable achievement of broodstock development in captivity and development of formulated larval and grow out feeds[10], under the first phase of the project, farming of hilsa in captivity is taking off in India. With the second phase of funding from ICAR now in place, the species is currently under various stages of standardisation of broodstock development, captive breeding, larval rearing, and pond based aquaculture. Along with the ongoing efforts to breed and farm the species in ponds, trials on stocking them in wetlands of similar nature, which are abundant in West Bengal, may also prove to be a viable option for scaling up hilsa production.

Acknowledgements

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